

Minimizing the RMS Surface Distortions from Gravity Loadings of the 34-m HA-DEC Antenna for Deep Space Missions

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The computer analysis of the 34-m HA-DEC antenna by the IDEAS program provided the rms distortions of the surface panels support points for full gravity loadings in the three directions of the basic coordinate system of the computer model. The rms distortions for the gravity vector not in line with any of the three basic directions were solved and contour plotted starting from three surface panels setting declination angle. By inspections of the plots, it was concluded that the setting or rigging angle of -15 degrees declination minimized the rms distortions for sky coverage of plus or minus 22 declination angles to 10 degrees of ground mask.

I. Introduction

A HA-DEC antenna has an axis of rotation parallel to the Earth's axis of rotation combined with a second rotation axis that is normal to the first axis. Sky coverage is thus obtained by the despinning action of the first (polar) axis with the elevation or declination angle pointing provided by the rotation about the second (declination) axis. The polar axis rotation is measured in hour angle (HA) and the declination axis rotation in plus or minus declination angle (DEC) from the equatorial plane of polar axis rotation.

At an Earth's location, the rotational motions of the antenna changes the direction of the gravity loading vector with respect to its structural symmetric plans and axis. This action results in variations of the reflective surface's distortion values, after best fit of a paraboloid.

II. Calculations

By assembling a full or complete structural computer model of the 34-m reflector structure, the design and analysis were done in the IDEAS program (Ref. 1). The analysis results (Table 1) were the rms (root-mean-squared) distortions of the surface panels' attach points with the applications of the full or 1.0-gravity loadings in the three directions of the cartesian coordinate system of the model. The cross-sectional areas of the reflector's truss members were changed in the IDEAS program through its iterative steps of designing cycles to minimize the rms distortions.

Using the method of analysis described in (Ref. 2), the rms distortion values of the 34-m HA-DEC antennas were plotted through the hour angle-declination angle ranges for several surface panels setting or rigging declination angle at zero hour

angle. Setting angles considered were at zenith look, at zero degrees declination, and at -15 degrees declination angles.

III. Results

The planetary missions normally confine the spacecraft to within plus or minus 22 degrees of declination angle values when the maximum gain capabilities of the ground antennas are required. By setting the surface panels at plus or minus 15 degrees declination angle, with the sign dependent on the hemisphere location, the rms distortion was minimized for full mission sky coverage above 10 degrees from ground mask.

This minimization is illustrated by Figs. 2, 3, and 4 showing the rms distortions for DSS 12 with the surface panels setting angles of zenith look, zero degrees declination angle, and -15 degrees declination angle. Figures 5 and 6 illustrate the rms distortions with the setting at -15 degrees declination for DSS 61 and +15 degrees declination for DSS 42.

Figure 1 describes the sign conventions used at the northern and southern hemisphere stations.

The latitude values are shown in Table 1 with the full or 1.0 gravity load values of the rms distortions for the three components loading directions as output by the IDEAS program.

IV. Summary

- (1) The rms distortions quoted are only for the surface panels' support points on the reflector structure.
- (2) For the selected observing ranges of plus or minus 22 degrees declination angles and 10 degrees elevation ground mask, the maximum rms distortion is 0.4 mm for the surface panels set at plus or minus 15 degrees declination, as required for the hemispheric requirement.

References

1. Levy, R., "Iterative Design of Antenna Structures," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. XII, pp. 100-111, December 15, 1972. Jet Propulsion Laboratory, Pasadena, California.
2. Katow, M. S. and Levy, R., "Computation of Gravity RMS for HA-DEC Antennas," in *The Deep Space Network Progress Report 42-27*, for March and April 1975, pp. 138-147. Jet Propulsion Laboratory, Pasadena, California.

Table 1. RMS distortions for full-gravity loads

Seq	DSS	Latitude, deg	RMS distortion for 1.0 gravity for component direction		
			X, mm	Y, mm	Z, mm
1	12 (Goldstone)	+35.20805	0.307	0.528	0.648
2	42 (Australia)	-35.21922	0.307	0.528	0.648
3	61 (Spain)	+40.23885	0.307	0.528	0.648

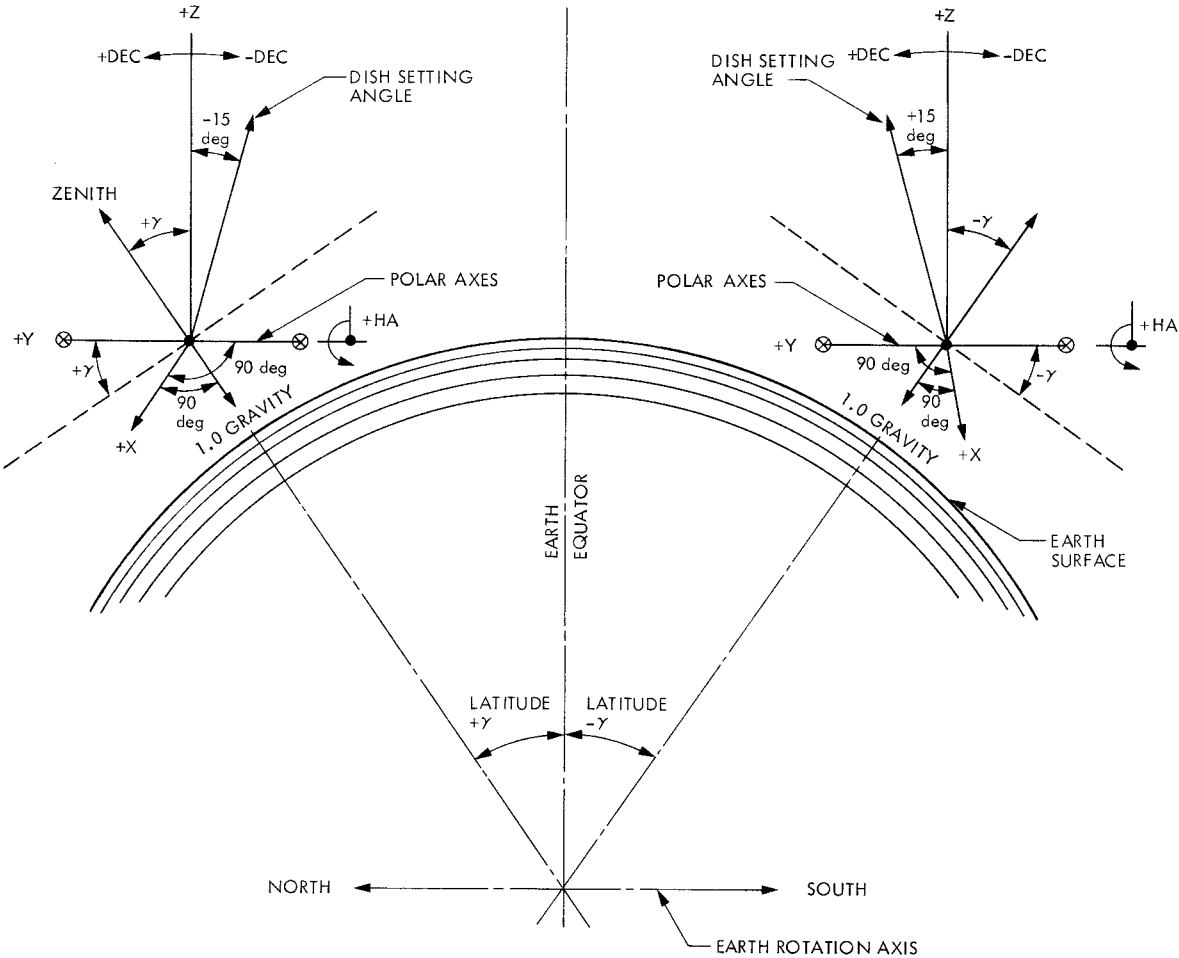


Fig. 1. Sign conventions – north and south hemisphere

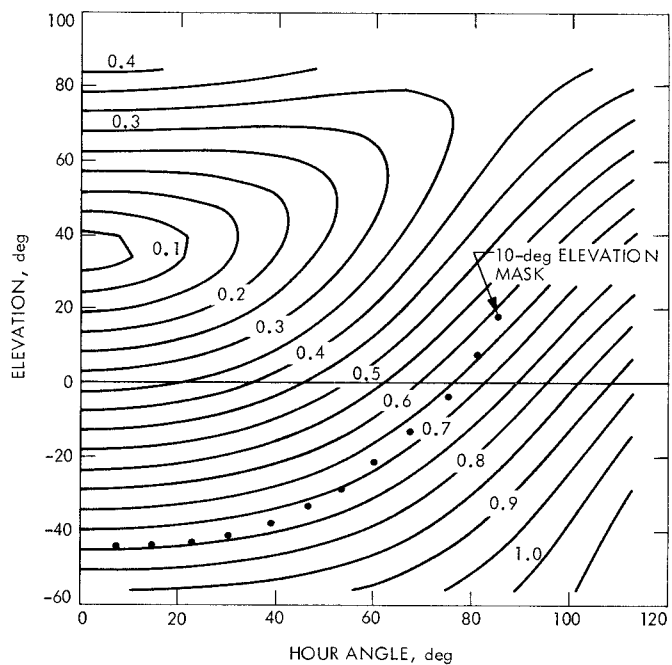


Fig. 2. DSS 12 surface panels set at zenith look; panels supporting points; rms distortion contour map, mm

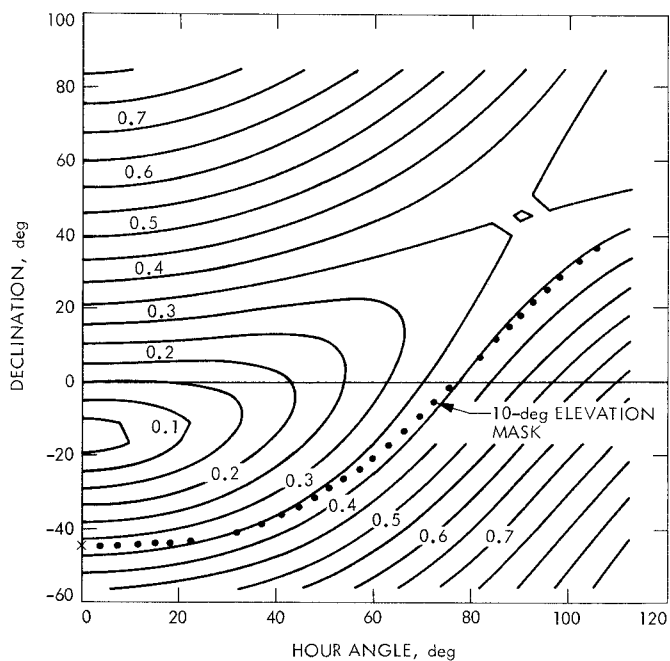


Fig. 4. DSS 12 surface panels set at -15° declination; panels supporting points; rms distortion contour map, mm

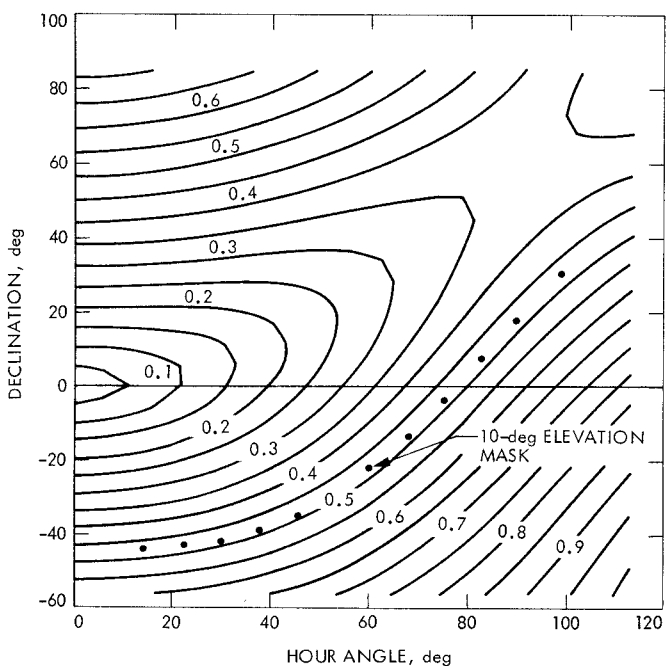


Fig. 3. DSS 12 surface panels set at 0° declination; panels supporting points; rms distortion contour map, mm

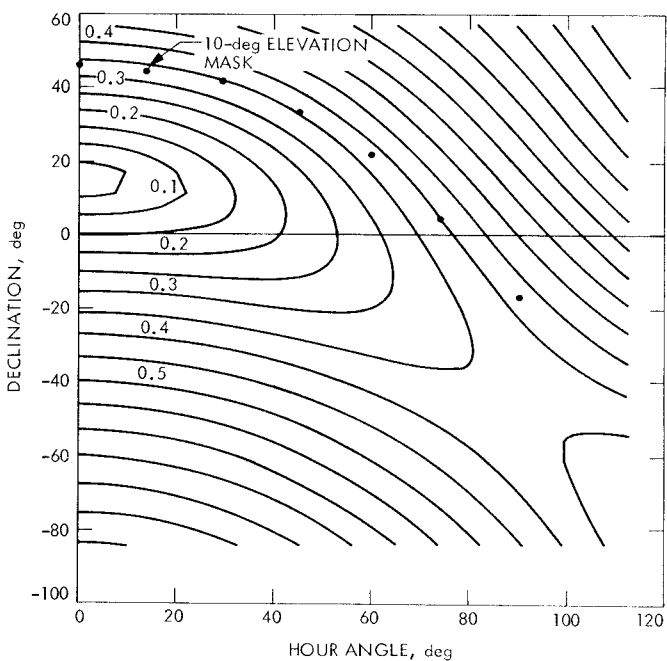


Fig. 5. DSS 42 surface panels set at -15° declination; panels supporting points; rms distortion contour map, mm

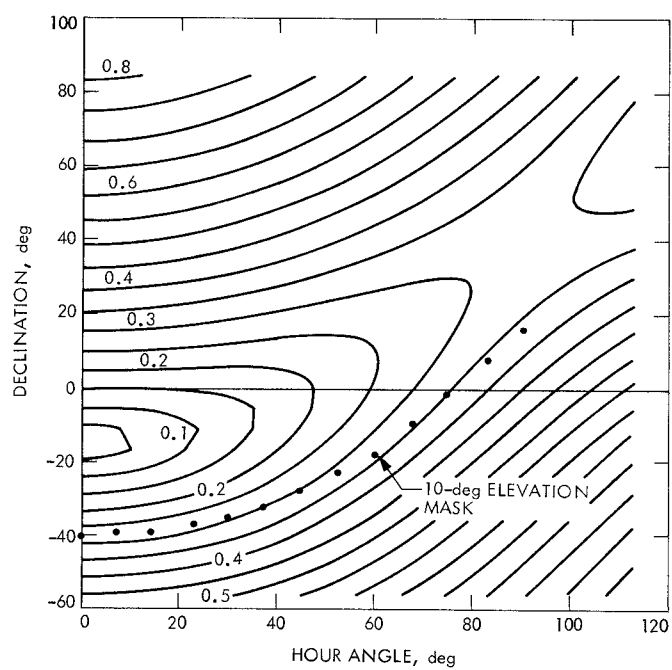


Fig. 6. DSS 61 surface panels set at -15 deg declination; panels supporting points; rms distortion contour map, mm